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ORIGINAL ARTICLE

Behavior of repeatedly loaded rectangular footings resting on reinforced sand

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Abstract The paper presents a laboratory study of the effect of geosynthetic reinforcement on the cumulative settlement of repeatedly loaded rectangular model footings placed on reinforced sand. Repeated load tests were carried out with different initial monotonic load levels to simulate structures in which live loads change slowly and repeatedly such as petroleum tanks and ship repair tracks. Three series of tests were carried out. Tests of series 1 were performed to determine the ultimate monotonic bearing capacity. Tests of series 2 were performed on unreinforced sand under vertical repeated loads. Tests of series 3 were performed to study the effect of sand reinforcement on the footing response under the same loads. The studied parameters include the initial monotonic load levels, the number of load cycles, and the relative density of sand along with geosynthetic parameters including size and number of layers. Both the ultimate bearing load and the cumulative settlement were obtained and analyzed.

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1. Introduction

Shallow foundations such as rectangular footings are widely used in transmitting loads from the superstructure to the supporting soils. After the foundation is constructed, the soil is permanently loaded by both the gravity loads and the live loads of the superstructure. In most constructions such as residential buildings, the live loads are much less than the gravity loads (own wt. of structure). However, in some structures, the live loads are greater than the dead loads of the structure itself and change with time, such as the loads of petroleum tanks and ship repair tracks. In petroleum tanks, petrol was transferred and stored in the tanks until it was carried to petroleum stations. Therefore, the supporting soil is subjected to repeated load whose frequency and load amplitude are dependent on the rate of filling and emptying the tanks. Also in the ship

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repair tracks, the ship loads are transferred to the footings during the ship repair and the load is removed totally by moving the ship to the sea. Several studies have been carried out to understand the behavior of model footings on sand deposits and subjected to cyclic loads. Raymond and Comos [1] studied the behavior of model strip surface footing under vertical cyclic load and reported that the permanent settlement increased as both the number of load cycles and the magnitude of cyclic load increased. Poulos et al. [2] carried out a series of model footing tests on sands with different relative densities under cyclic vertical loading conditions. Sawicki et al. [3] reported test results of strip and circular model footing supported on dry fine to medium sand and subjected to cyclic vertical load, the magnitude of which was equal to some fraction of the foundation bearing capacity.

Several studies have reported the successful use of soil reinforcement as a cost-effective method to increase the ultimate bearing capacity and to decrease the settlement values under shallow footings to accepted limits [4–8]. This was achieved by the inclusion of multiple layers of geogrid at different depths and widths under the footings. This reinforcement consists of a series of interlocking cells which contain and confine the soil within its pockets creating an interlocking action between the sand and the grid. This interlock enables the geogrid to resist the horizontal shear stresses built up in the soil mass under the footing and to transfer them to the adjacent stable layers of soils and thereby improve the vertical behavior of the footing. However, few studies have focused on the behavior of shallow footing subjected to cyclic loading and resting on reinforced sand. Yeo et al. [9] and Das et al. [10] studied the ultimate bearing capacity and the settlement of square and strip model footings supported on geogrid reinforced sand and subjected to the sum of static load and vertical cyclic load of different intensities. Raymond [11] studied the effect of geosynthetic reinforcement on the settlement of a plane strain footing supported on a thin layer of granular aggregate overlying different compressible bases and subjected to repeated load which returned to zero at the end of each cycle to simulate a vehicle loading on a track support. Shin et al. [12] reported laboratory model tests results of the permanent settlement of the subbase layer reinforced with geogrid layers due to cyclic load of the railroad.

Most of the previous studies deal with the behavior of reinforced sands under cyclic vertical loads simulating either train and vehicle loads or sum of static loads and cyclic loads of high frequencies. To the best knowledge of the authors, the settlement of reinforced sand bed subjected to slowly repeated load simulating a loading condition such as the case of petrol tanks has not yet been investigated. Hence, many questions still remain such as the effect of such repeated loads on both the

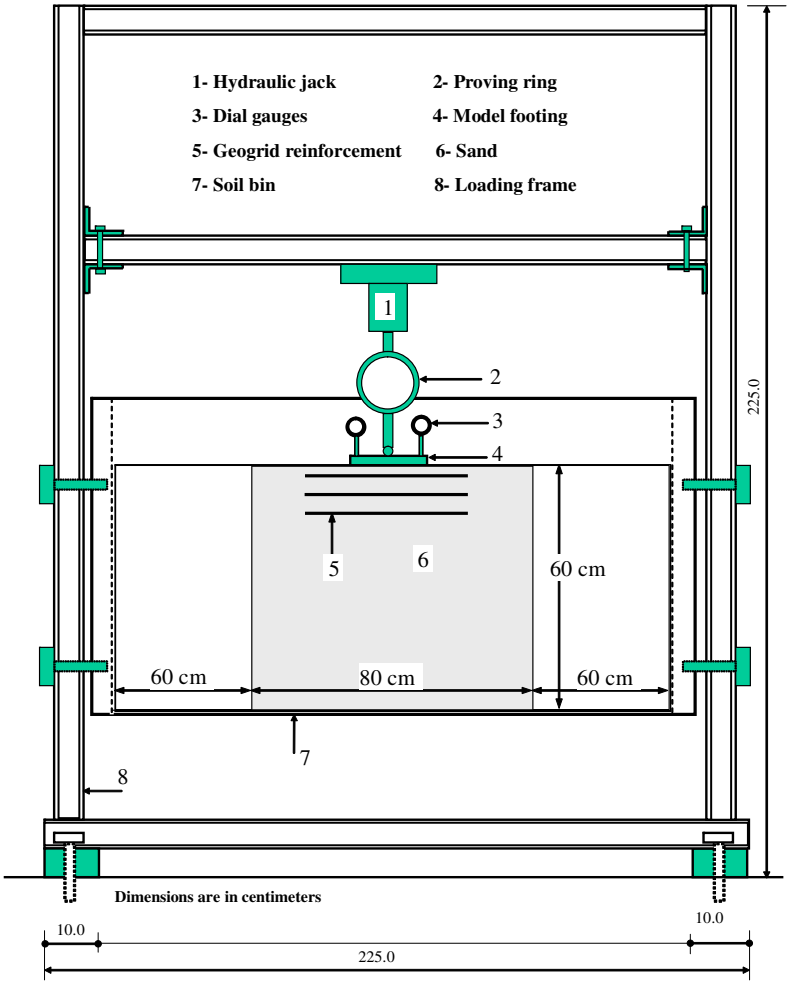

Figure 1 Overall view of the experimental apparatus.

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